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Environmental Assessment

Red Dog Mine Project NPDES Permit Modification
Northwest Alaska

Teck Cominco Alaska, Inc.

NPDES Permit No. AK-003865-2

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With Technical Assistance from:

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1.0 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Background

The Red Dog lead and zinc mine is located in northwest Alaska, approximately 80 miles north of Kotzebue and about 50 miles inland from the Chukchi Sea (Figure 1). The mine site is located on Red Dog Creek in the DeLong Mountains. In the early 1980s, Teck Cominco Incorporated submitted several applications for federal authorizations for the project. One of the applications was for a National Pollutant Discharge Elimination System (NPDES) permit to discharge wastewater to Middle Fork Red Dog Creek. The surface water discharge was a new source in accordance with 40 CFR 122.2. As a result, 40 CFR Part 6, the Agency's implementing regulations for the National Environmental Policy Act, required EPA to prepare an Environmental Impact Statement (EIS) on the potential environmental impacts of the proposed operation. EPA issued that EIS in 1984 (USEPA/DOI 1984).

The original NPDES permit issued to the mine (AK-003865-2) expired in 1990. In its application for a permit renewal, Teck Cominco requested an increase in the volume of effluent that it was permitted to discharge. The requested change was outside the range of alternatives considered in the original EIS and therefore raised issues not addressed in the original EIS. As a result, EPA prepared an Environmental Assessment (EA) that evaluated potential impacts of the increase in effluent discharge volume and selected alternatives (USEPA 1993). EPA subsequently made a Finding of No Significant Impact (FONSI) and reissued the permit on August 28, 1998.

The 1998 NPDES permit included metals limits that were significantly more stringent than the metals limits in the original NPDES permit. The permit also included limits for total dissolved solids (TDS) based on the State's narrative water quality criterion for aquatic life use, which limited the concentration of TDS to "one-third above background." Based on measured in-stream background concentrations the limits were set at 176 mg/L (monthly average) and 196 mg/L (daily maximum). Teck Cominco has not been able to meet the permit limits for TDS that are in the 1998 permit.

Teck Cominco uses lime precipitation and sodium sulfide precipitation in its wastewater treatment process to lower the concentration of toxic metals in the wastewater. This treatment process introduces TDS into the mine's effluent. Currently, there is no proven technology to remove TDS from wastewater at the flow volumes that need to be discharged by the facility.

The water in the tailings impoundment is near capacity. Because the water in the tailings impoundment is highly toxic to aquatic life and human health it is critical to maintain the water in

Figure 1 - Red Dog Mine

the tailings impoundment at a level that will ensure that the structural integrity of the tailings impoundment is maintained. To do this the mine must discharge all of the mine drainage (i.e., rainfall and snowmelt that comes into contact with exposed ore) that is collected in the tailings impoundment each year. There is no known way to avoid or reduce the discharge, or the metals loading that must be treated, since the discharge primarily consists of mine drainage.

On July 2, 1999, EPA and Teck Cominco entered into a Compliance Order by Consent (Modified Compliance Order no. CWA-10-99-0167, date May 17, 2002). The order, which was modified in 2000, 2001, and 2002, established:

1. Conditions under which Teck Cominco could discharge
2. A deadline for compliance with the permit's TDS limits (the 2003 discharge season)
3. Interim TDS limits at various in-stream monitoring stations, and
4. Monitoring and reporting requirements.

In 1999, the Alaska Department of Environmental Conservation (ADEC) revised its state-wide water quality regulations (18 AAC 70) to delete the "one-third above background" narrative criterion for TDS. The criterion was replaced with "not-to-exceed" limits that depend on the designated beneficial use classification. The aquatic life use classification can allow a TDS criterion value of 1,000 mg/L. However, as stated in the 1999 revisions:

> If a permit applicant proposes to raise the TDS levels in the receiving water to result in a concentration in the waterbody between 500 mg/l and 1,000 mg/l for all sources or above 110 mg/l for the potassium ion, the department will require a permit applicant to provide information that the department identifies as necessary to determine if the proposed TDS level will cause or can reasonably be expected to cause an adverse effect on aquatic life; based on its analysis, the department will limit the TDS level in the waterbody as necessary to prevent an adverse effect, and will set permit effluent limits accordingly; the burden of proof to demonstrate no adverse effect is on the permit applicant; implementation of the "no adverse effect" criterion is not subject to 18 AAC 70.235.

Table 1, below, summarizes the use classifications for each stream segment, and the most stringent criterion applicable to each stream segment.

Table 1. Use Classifications and TDS Criteria for Area Streams

Stream Reach	*Use Classifications*	*TDS Criterion for the Most stringent Use Classification*
Upper Middle Fork Red Dog Creek (Headwaters to terminus of the Red Dog mine water management system)	**Industrial water supply**	No amounts above natural conditions that can cause corrosion, scaling or process problems.
Lower Middle Fork Red Dog Creek (Terminus of the Red Dog mine water management system to confluence with North Fork Red Dog Creek)	**Industrial water supply** Contact recreation (wading only) Secondary recreation (except fishing)	No amounts above natural conditions that can cause corrosion, scaling or process problems.
Mainstem Red Dog Creek (Confluence of North Fork Red Dog Creek to confluence of Ikalukrok Creek)	**Aquatic life** Industrial water supply Contact recreation (wading only) Secondary recreation	May not exceed 1,000 mg/L; may not be present in a concentration that causes an adverse effect to aquatic life.
Ikalukrok Creek	**Aquatic life** Industrial water supply Contact recreation (wading only) Secondary recreation	May not exceed 1,000 mg/L; may not be present in a concentration that causes an adverse effect to aquatic life.
NOTE: The TDS criterion listed is associate with the use classification that is in bold letters.		

In January 2001, Teck Cominco submitted a request to ADEC to establish a site-specific water quality criterion for TDS in the Mainstem Red Dog Creek. Teck Cominco requested an in-stream TDS criterion of 1,500 mg/L (maximum) which would apply after resident Arctic grayling finish spawning (this occurs when there is free-flowing water after ice breakup, usually in late May or early June).

Teck Cominco also requested that ADEC approve a permit limit for TDS that allows 1,000 mg/L (maximum) in Ikalukrok Creek from its confluence with Mainstem Red Dog Creek to its confluence with the Wulik River. This limit would apply at all times except during the spawning period. During spawning periods, in spawning areas, the permit limit would be based on the TDS criterion of 500 mg/L (maximum). Spawning in Ikalukrok Creek occurs approximately 9.5 miles downstream of Dudd Creek (see Figure 1) from July 25th through the end of the discharge season (i.e., the facility ceases its discharge for the year when the creeks start to freeze up, the exact time will vary from year to year).

Teck Cominco also requested that ADEC modify its certification of the Red Dog Mine NPDES permit to include the above TDS criteria and to authorize two mixing zones: one in Mainstem Red Dog Creek and the other in Ikalukrok Creek. A mixing zone is an area in a waterbody downstream of the discharge, where the effluent is diluted by the receiving water. Within the mixing zone the TDS criterion can be exceeded locally due to incomplete mixing of effluent and the receiving water. Outside of the mixing zone

the criterion must be met. The proposed mixing zone in Mainstem Red Dog Creek would begin at the confluence with North Fork Red Dog Creek and continue downstream for 1,930 feet. The proposed mixing zone in Ikalukrok Creek would start at the confluence with Mainstem Red Dog Creek and continue downstream for 3,420 feet.

Effluent flow from the mining facility outfall, which would be subject to an end-of-pipe flow limit, would be adjusted as necessary to avoid exceeding the applicable criterion outside of the applicable mixing zone. Teck Cominco (Teck Cominco Alaska, Inc 2000b) has developed a TDS/conductivity model that can be used to adjust outfall flows to meet the criteria. Under Teck Cominco's request, modification of ADEC's certification, which serves as the State's wastewater disposal permit, would incorporate the site-specific criterion for Mainstem Red Dog Creek, the 1,000 mg/L criterion for Ikalukrok Creek (except during spawning periods), and the proposed mixing zones in Mainstem Red Dog Creek and Ikalukrok Creek.

Teck Cominco will request a modification of the NPDES permit to reflect the changes outlined above.

1.2 Purpose and Need for Proposed Action

As noted earlier, the volume of wastewater that the mine discharges is dictated by the precipitation amount, and safety considerations in connection with the tailings impoundment. In order to meet the applicable metals limits for that discharge, Teck Cominco must introduce more TDS into its wastewater than its current permit allows. It is important to modify the permit to allow Teck Cominco to discharge enough wastewater to preserve the tailings impoundment's structural integrity, and remove enough metals from the wastewater in order to ensure that the metals are at concentrations that will be protective of water quality.

The proposed action involves a change in one water quality parameter, TDS, and the inclusion of two mixing zones in the existing NPDES permit. The permit modification is premised on changes made to the state-wide water quality standards for TDS, the State's proposed modification of the certification of the NPDES permit, and a TDS site-specific criterion for Mainstem Red Dog Creek the State is developing in response to Teck Cominco's request. The implementing regulations for the NPDES program allow a permit to be modified when the standards on which the permit was based have been changed, or when a state certification for the permit has been modified.

1.3 Scope of this Environmental Assessment

This document constitutes an Environmental Assessment that has been prepared to support a proposed modification of the Red Dog Mine NPDES permit by EPA in response to changes in the State's water

quality standards, and the State's certification (under Clean Water Act Section 401) of the mine's NPDES permit. Consequently, the analyses in this EA are restricted to matters directly related to the proposed change in the NPDES permit and the reasonable alternative. The affected environment described herein is limited to water resources, aquatic life, and human health. Other environmental resources, such as soils, vegetation, wildlife, air quality, land use, and socioeconomics are not expected to be affected in any way by the proposed action. Descriptions of these resources can be found in previous environmental assessments associated with the Red Dog Mine, to which the reader is referred (USEPA/DOI 1984; USEPA 1993). This EA was prepared in compliance with NEPA regulations of the Council on Environmental Quality (40 CFR Parts 1500-1508) and EPA (40 CFR Part 6).

2.0 Description of the Proposed Action and Alternative

This chapter describes the proposed action and an alternative to the proposed action.

2.1 Proposed Action and Alternative

2.1.1 Proposed Action: Modify TDS Limits in NPDES Permit

The proposed action is to grant Teck Cominco's request for modification of Red Dog Mine's NPDES permit. The modified permit would amend effluent limits for TDS to ensure Alaska's new water quality criteria for TDS are met in Mainstem Red Dog Creek and Ikalukrok Creek outside of the proposed mixing zones, and in spawning areas during spawning periods.

The proposed permit contains the following requirements:

1. No discharge is allowed until after Arctic grayling have completed spawning.

2. In Mainstem Red Dog Creek, after the end of Arctic grayling spawning (at which time there is free-flowing water, typically late May or early June), the permittee must regulate its effluent discharge so that the TDS level in the stream, outside of the proposed mixing zone, does not exceed 1,500 mg/L at any time.

   The proposed mixing zone is 1,930 feet downstream from the North Fork confluence. A water quality monitoring station, Station 10, is located 1.2 miles (about 6,300 feet) below the confluence of North Fork Red Dog Creek. Station 10 should adequately reflect the water quality conditions at the edge of the proposed mixing zone since the effluent and receiving

water are fully mixed at the edge of the mixing zone and there are no other tributaries to Main Stem Red Dog Creek between Station 10 and the edge of the proposed mixing zone. Therefore, the permit will require monitoring at Station 10 to ensure that the criterion is being met outside of the proposed mixing zone. See Figure 1 for the location of Station 10.

3. In Ikalukrok Creek, the permittee must regulate its effluent discharge so that the TDS level in the stream, outside of the proposed mixing zone, does not exceed 1,000 mg/L. However, when spawning is occurring in Ikalukrok Creek, the requirement in bullet 4 (below) must be met instead.

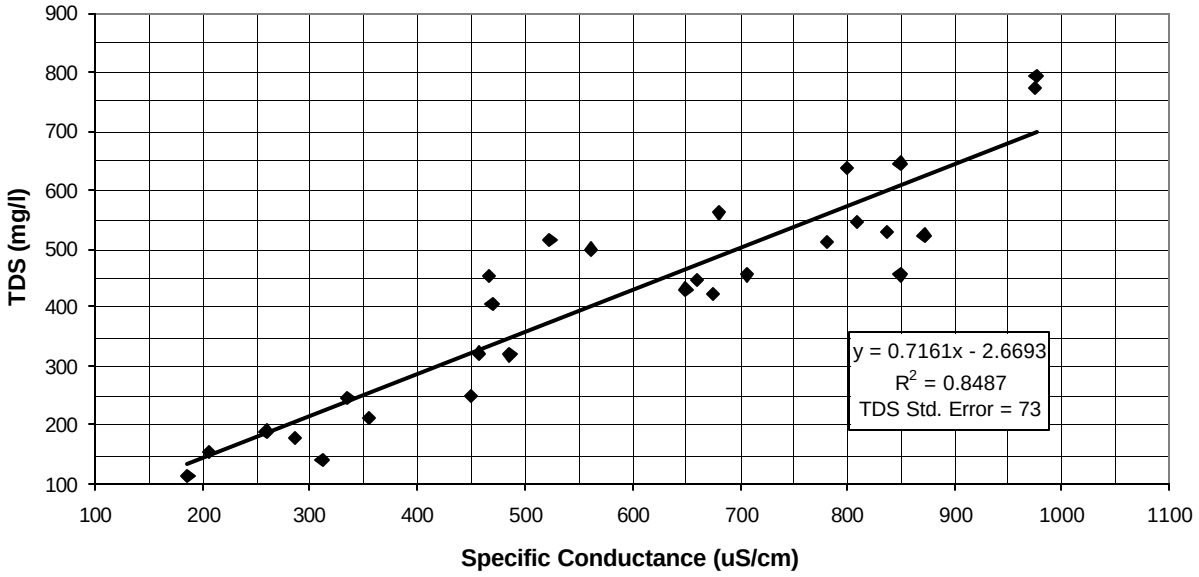
   Station 150 is a water quality monitoring station located in Ikalukrok Creek about 150 feet downstream of the edge of the proposed mixing zone in Ikalukrok Creek (the proposed mixing zone is 3,420 feet downstream from the Mainstem Red Dog Creek confluence). Station 150 should adequately reflect the water quality conditions outside of the proposed mixing zone since Mainstem Red Dog Creek and Ikalukrok Creek are fully mixed at the edge of the mixing zone and there are no other tributaries to Ikalukrok Creek between Station 150 and the edge of the proposed mixing zone. Therefore, the permit will require monitoring at Station 150 to ensure that the criterion is being met outside of the proposed mixing zone. See figure 1 for the location of Station 150.

4. During the salmon and Dolly Varden spawning period in Ikalukrok Creek (July 25 through the end of the discharge period), the permittee must regulate its effluent discharge so that the TDS level in the stream, where spawning occurs, does not exceed 500 mg/L.

   Station 160 is a water quality monitoring station located in Ikalukrok Creek about 3 miles below the confluence of Dudd Creek. It is located above the known spawning areas in Ikalukrok Creek. Therefore, the permit will require monitoring at Station 160 to ensure that the criterion is being met in spawning areas during spawning periods. See Figure 1 for the location of Station 160, Dudd Creek, and spawning areas.

   There is some Dolly Varden spawning habitat in Ikalukrok Creek at the mouth of Dudd Creek. Teck Cominco collected TDS samples at several transects across Ikalukrok Creek, at the mouth of Dudd Creek, as well as vertical profiles of the water quality. Results from the monitoring show that this spawning habitat is composed primarily of Dudd Creek water with little input from Ikalukrok Creek. Therefore the TDS level will reflect the water quality in Dudd Creek and not the effluent, so additional monitoring will not be required in this area.

Figure 2
TDS - Conductivity Correlation at Station 73
Based on 1999 and 2000 Data



The proposed permit requires Teck Cominco to monitor TDS by direct laboratory testing at stations 10, 150 and 160. Additionally, Teck Cominco has installed transmitters at stations 10 and 160 which provide in-stream data to the mill. The stations have data loggers which can measure and record stream flow and TDS concentrations. TDS is determined by using conductivity correlation curves (plotting TDS and specific conductance paired data and applying a linear regression). The correlation curves are updated each year and will continue to be updated each year as more information is gathered. The data are then transmitted to the mill twice each day, and will be used by the plant operators to adjust the outfall discharge in order to maintain the TDS concentrations within the permit limits (bullets 2-4 above). Figure 2 provides an example of a TDS-conductivity correlation at Station 73.

Teck Cominco has collected TDS data at Station 150 on Ikalukrok Creek since 2001. Spawning does not occur in this section of Ikalukrok Creek; therefore, the applicable criterion is 1,000 mg/L. The data collected over the last two years show that the TDS criterion of 1,000 mg/L will be met at Station 150 whenever the TDS criterion in Mainstem Red Dog Creek is at or below 1,600 mg/L. Since, the proposed permit requires the TDS concentration in Mainstem Red Dog Creek to be at or less than 1,500 mg/L, the proposed permit does not require Teck Cominco to install a transmitter in Ikalukrok Creek at Station 150 or to collect daily in-stream data.

2.1.2 Alternative: Maintain TDS Limits in Current NPDES Permit

Under the alternative, EPA would not change the TDS limits that are in the existing NPDES permit.

Instead, EPA would retain effluent limits for TDS of 170 mg/L (monthly average) and 196 mg/L (daily maximum). In order to meet these limits, Cominco would have to install additional water treatment to reduce TDS approximately 95 percent from the nominal concentrations in raw effluent, which ranged from about 1,710 to 3,630 mg/L with a median value of 3,430 mg/L in 2002.

3.0 The Affected Environment

As noted in Section 1.3, the scope of this EA includes only potential impacts from the proposed modification of the existing NPDES permit, and the alternative. These actions would affect only water resources, aquatic life, and human health. Therefore, the discussion of the affected environment in this EA is restricted to these resources. EPA/DOI 1984 and EPA 1993 contain discussions of the potential impacts of the Red Dog Mine on other resources, such as soils, vegetation, air quality, land use and socioeconomics, which this proposed action does not affect. Figure 1 shows the locations of monitoring stations where stream flow and water quality data have been collected.

3.1 Water Resources

3.1.1 Hydrology and Stream Flow

Hydrology information is detailed in USEPA/DOI 1984. Seasonal stream flows vary significantly in the Arctic environment of the mine site, with virtually all flow occurring in the five-month period from spring thaw in May to winter freeze in October. Storm runoff can vary significantly depending on topography, degree of soil saturation, and depth to the frozen layer. Small tributary streams typically freeze to the bottom in the winter months, whereas larger rivers can continue to flow beneath an ice covering.

Red Dog Creek. Red Dog Creek, which drains the western foothills of the DeLong Mountains, including the Red Dog Mine site, flows into Ikalukrok Creek, a major tributary of the Wulik River (Figure 1). The stream has two major tributaries (Middle Fork and North Fork) that combine to form Mainstem Red Dog Creek. A third tributary, the South Fork, was impounded to form the tailings impoundment and no longer flows to its natural confluence with the Middle Fork. The Red Dog Mine facilities, including the Red Dog Mine pit and Red Dog Creek diversion, are contained within the drainage areas of Middle and South Fork Red Dog Creek.

North Fork Red Dog Creek drains approximately 41 km^2. The stream is typically from 7 to 15 meters wide and from 0.09 to 2 meters deep (ADF&G, 1999). It is characterized by riffles and pools that flow over substrate of gravel and boulders. Middle Fork Red Dog Creek drains approximately 12 km^2. This

segment is a meandering channel that is 3 to 10 meters wide and 0.03 to 0.45 meters deep. Mainstem Red Dog Creek drains approximately 64 km^2 (ADF&G, 1999). Mainstem Red Dog Creek flows across a substrate of gravel, cobbles, and small boulders. This creek meanders and has widths ranging from 3.5 to 18 meters wide and depth between 0.06 to 0.5 meters.

Figure 3 shows the mean flow in Mainstem Red Dog Creek, as measured at Station 10 from 1994 to 2000. The creek is generally frozen during winter months. The creek flow averages approximately 200 cfs during ice breakup in late May.

Table 2 shows the minimum, maximum, and median flows for the outfall, station 10, station 73, station 7 (located in Ikalukrok Creek below Dudd Creek), and station 2 (in the Wulik River below the confluence of Ikalukrok Creek). The flows represent data collected from 1999 through 2002. During these years the facility discharged at flow rates similar to the limits in the proposed permit modification. The flow at Station 10 ranges from 0 to 620 cfs with a median value of 45 cfs (late summer storms can cause fluctuating high flows ranging up to 620 cfs). Approximately 26 percent of the median flow is from the mine outfall discharge.

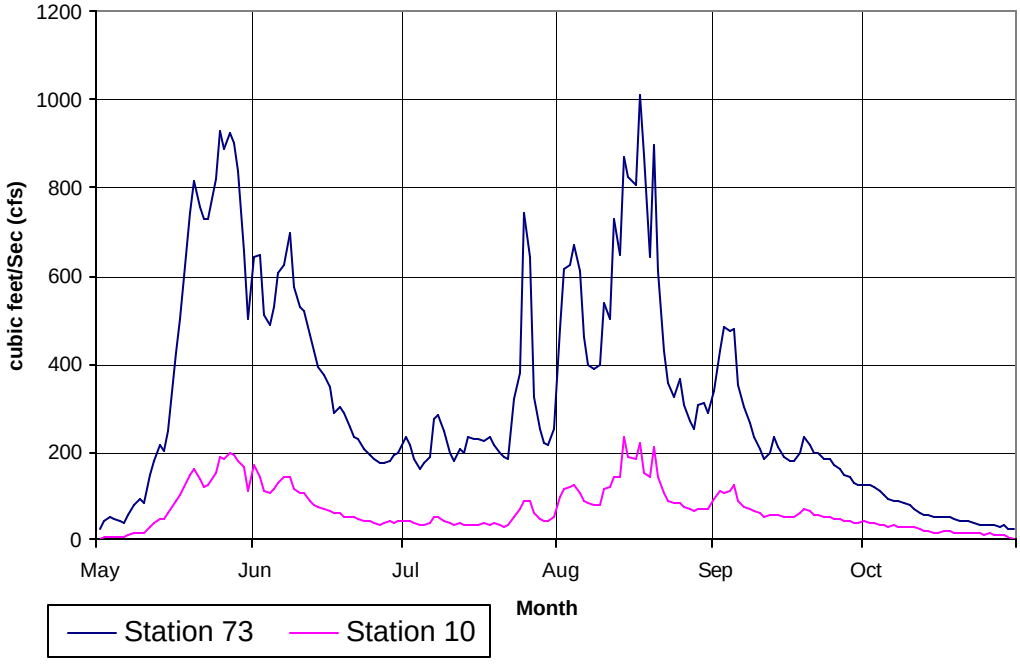
Table 2. Flow Discharge Rates in cfs
1999-2002

	Outfall Discharge	Station 10 (Mainstem Red Dog Creek)	Station 73 (Ikalukrok Creek below Mainstem Red Dog Creek)	Station 7 (Ikalukrok Creek below Dudd Creek)	Station 2 (Wulik River below Ikalukrok Creek)
Minimum	0.0	0.0	2	2	13
Maximum	29	620	2600	3300	21300
Median	12	45	161	239	994
Count	676	664	664	366	665

Ikalukrok Creek. Ikalukrok Creek flows approximately 25 miles to the Wulik River which, in turn, flows approximately 30 miles to the Chukchi Sea. Near the headwaters of Ikalukrok Creek, the stream flows through areas of natural mineralization (ADF&G, 1999).

Ikalukrok Creek above the confluence with Mainstem Red Dog Creek drains approximately 150 km^2. This segment, which has not been disturbed by human activity, has a substrate of cobbles, gravel, and rocks. At Station 9, in Ikalukrok Creek above the confluence of Mainstem Red Dog Creek the rocks in the stream bed are frequently stained orange from naturally occurring iron precipitate (ADF&G, 1999).

Figure 3. Mean Flow Rates in Mainstem Red Dog Creek (Station 10) and Ikalukrok Creek (Station 73), 1994-2000



In this reach, Ikalukrok Creek is typically 2 to 7 meters wide (up to 20 meters during high flow), with depths of 0.15 to 1.2 meters. Below the confluence with Mainstem Red Dog Creek, Ikalukrok Creek is a comparatively fast-flowing stream with a substrate of small cobbles and gravel. ADF&G (1999) reported a dense growth of filamentous algae and iron precipitate on the stream bottom at Station 8 (located in Ikalukrok Creek just below the confluence of Mainstem Red Dog Creek, see figure 1). Gravel bars are exposed during low flow. Ikalukrok Creek below the Dudd Creek confluence ranges in wetted-width from 3.5 to 40 meters and in depth from 0.3 to 1.2 meters. The substrate in this location consists of small to medium sized gravel (ADF&G, 1999).

Average seasonal flow at Station 73, in Ikalukrok Creek below the Mainstem confluence, is highly variable (Figure 3). Essentially all stream flow occurs from mid-May through mid-October. Due to the presence of shallow permafrost and saturated soils, rapid snowmelt or rainfall results in rapid changes in stream discharge. Surface discharge volume peaks in late May during ice breakup and during summer storms. Peak flow volume may exceed 1,500 cfs during these periods. Flow decreases with the onset of winter (September/October) and by mid-winter the creek is substantially frozen, although intermittent aufeis fields may form from ice pressure. Based on data from years 1999-2002, the flow at Station 73 ranged from 2 cfs to 2,600 cfs with a median value of 161 cfs (Table 2). Approximately 7 percent of the median flow is attributable to the mine outfall discharge.

In Ikalukrok Creek downstream of Dudd Creek at Station 7 (see location on Figure 1), flows generally range between 2 and 3,300 cfs, with a median flow of 239 cfs. Approximately 5 percent of the median flow is attributable to the mine outfall.

Flow in the Wulik River, as measured for the years 1999-2002 at Station 2 (lower Wulik River below the confluence of Ikalukrok Creek) ranged from 13 cfs to 21,300 cfs with a median flow of 994 cfs. Approximately 1% of the median flow is attributable to the mine outfall.

3.1.2 Surface Water Quality

Teck Cominco treats Red Dog Mine wastewater to reduce metals and other constituents to concentrations required in the NPDES permit. This treatment results in increased TDS concentrations in the receiving waters. Lime, containing calcium, and sodium sulfide are the primary additives used to remove metals from the wastewater. Based on available analytical data, the effluent TDS concentration in 2002 was between 1,710 mg/L and 3,640 mg/L, with a median concentration of 3,430 mg/L. The approximate percent composition of ions in the effluent TDS was:

Potassium - 0.5 %
Chloride - 0.5 %
Sodium - 1 %
Magnesium - 2 %
Calcium - 24 %
Sulfate - 72 %

Most of these ions are typically found in natural waters but at lower concentrations. Sulfate is the predominant ion in this TDS mixture. Table 3 summarizes available TDS concentration data for Red Dog and Ikalukrok Creeks.

TABLE 3. Summary of TDS Concentrations in Red Dog Creek and Ikalukrok Creek

TDS	North Fork Red Dog Creek (unaffected by effluent)	Mainstem Red Dog Creek	Ikalukrok Creek, below Mainstem Red Dog Creek	Ikalukrok Creek, below Dudd Creek
	Station 12 (1999-2002)	Station 10 (1999-2002)	Station 150 (2001-2002)	Station 160 (1999-2002)
Minimum	19	50	68.8	50
Maximum	776	1,820	788	876

TABLE 3. Summary of TDS Concentrations in Red Dog Creek and Ikalukrok Creek

TDS	North Fork Red Dog Creek (unaffected by effluent)	Mainstem Red Dog Creek	Ikalukrok Creek, below Mainstem Red Dog Creek	Ikalukrok Creek, below Dudd Creek
	Station 12 (1999-2002)	Station 10 (1999-2002)	Station 150 (2001-2002)	Station 160 (1999-2002)
Median	275	1090	413	368
Count	48	115	73	97

See Figure 1 for station locations, and see Section 1.1.2. for a description of the applicable criteria, proposed mixing zones, and spawning areas.

Red Dog Creek. In general, higher concentrations of TDS are correlated with high discharges of mine effluent and low stream flows. The concentrations of TDS are substantially higher in Mainstem Red Dog Creek than upstream in North Fork Red Dog Creek.

Table 3 summarizes the results of TDS monitoring at Station 10 from 1999 through 2002. These data show that TDS concentrations vary substantially under the present discharge conditions. Sixteen of 115 measurements (~14 percent) exceeded 1,500 mg/L TDS, which is the site-specific criterion value proposed for the proposed permit. However, it should be noted that the compliance order which the facility was operating under allowed the facility to discharge up to 1,600 mg/L for up to 48 hours in any 10-day period; only three of the 115 measurements (~3 percent) exceeded 1,600 mg/L.

Ikalukrok Creek. As can be seen from Table 3, in general, the median concentrations of TDS at Stations 150 and 160 are about one third the concentration at Station 10 in Mainstem Red Dog Creek. None of the measurements at Station 150 exceeded the proposed TDS criterion of 1,000 mg/L TDS, and only one of the measurements at station 160 exceeded the TDS criterion of 500 mg/L that would be applicable during the spawning season.

3.2 Aquatic Resources

Aquatic resources and fisheries have been described in several ADF&G publications (ADF&G 1990; 1992; 1993; 1994; 1996a,b; 1998; 1999; 2000; 2001a;2002a). In addition, aquatic resources were described in earlier baseline reports (EVS and Ott Water Engineers 1983; EPA/DOI 1984; Dames and Moore 1981, 1983).

3.2.1 Fish

Arctic grayling (*Thymallus arcticus*) When break-up occurs (usually in late May), adult Arctic grayling migrate upstream in Ikalukrok Creek to Mainstem Red Dog Creek and into North Fork Red Dog Creek. They begin spawning when water temperatures reach 4°C. They feed on benthic invertebrates and terrestrial insects. Fry hatch in late June and rear in the North Fork Red Dog Creek until fall. In late August or September, young-of-the-year and adults migrate downstream to overwintering areas in Ikalukrok Creek or the Wulik River. ADF&G (1998) found grayling young- of-the-year in lower Mainstem Red Dog Creek (Station 10) in late June and September 1997, suggesting that Arctic grayling spawn in lower Mainstem Red Dog Creek (ADF&G 2002b). Use of Mainstem Red Dog Creek by Arctic grayling adults and young-of-the-year in the past few years appears to be increasing (ADF&G 1998).

Dolly Varden char (*Salvelinus malma*) Approximately 90 percent of overwintering Dolly Varden in the Wulik River drainage occur in the Wulik River downstream of the mouth of Ikalukrok Creek (ADF&G 1998). Dolly Varden spawn in the fall. Spawning has been documented in Ikalukrok Creek below station 160 and near the confluence of Ikalukrok Creek and Dudd Creek and in Dudd Creek. Juvenile distribution is broader than that of adult spawners. Juveniles have been collected in Mainstem and North Fork Red Dog Creek and in Ikalukrok Creek. Dolly Varden juveniles were first documented in the North Fork of Red Dog Creek in 1992.

Chum salmon (*Oncorrhynchus keta*) Chum salmon are found in Ikalukrok Creek. They spawn in the lower 9.5 mile reach of Ikalukrok Creek below Dudd Creek from late July through August (ADF&G 2002a). The population in this reach increased after the early 1990s, presumably due to the construction of a diversion ditch at the Teck Cominco mine site. However, chum abundance remains below pre-mining abundance estimates (ADF&G 1998). The 2001 surveys conducted by ADF&G counted 2,250 adult chum salmon - the highest number since mining began (ADF&G 2002b).

Chinook and Sockeye Salmon Both chinook and sockeye salmon are present in the system. Prior to construction of Red Dog Mine, chinook salmon used Ikalukrok and Dudd Creeks for spawning (Dames and Moore 1983). In field surveys conducted in 1997, eight sockeye salmon were observed in lower Ikalukrok Creek (ADF&G 2002b). In 2001, two chinook salmon were observed on a redd in lower Ikalukrok Creek; thus, this area is considered a chinook spawning reach. Data on sockeye salmon distribution and abundance are very limited.

Slimy sculpin (*Cottus cognatus*) Slimy sculpin have been observed in the North Fork and were caught for the first time in the Mainstem of Red Dog Creek in 1995. Slimy sculpin also occur in Ikalukrok Creek.

Table 4 summarizes fish presence by life history stage in the major stream segments. Fish have not been observed in the Middle Fork Red Dog Creek at any time, including the pre-mining period. The winter distribution of all fish species appears to be limited to Ikalukrok Creek downstream of the confluence with Dudd Creek and in the Wulik River. There are no threatened or endangered species or critical habitats in or near the waters that may be affected by the proposed change in the TDS limits.

Table 4. Fish Use in the Project Area			
Creek Segment	**Spawning**	**Rearing**	**Juvenile Outmigration**
North Fork Red Dog Creek	AG	AG, DV, SS	AG, DV, SS
Middle Fork Red Dog Creek	--	--	--
Mainstem Red Dog Creek	AG [c]	AG, DV, SS	AG, DV, SS
Ikalukrok Creek upstream of Red Dog Creek [a]	AG [c]	AG, DV, SS	AG
Ikalukrok Creek between Red Dog Creek and Dudd Creek	AG	AG, DV	AG, DV, SS
Ikalukrok Creek downstream of Dudd Creek [b]	DV, Chum Chin, SK [c]	DV	DV

AG = Arctic grayling, DV = Dolly Varden, SS = Slimy Sculpin, Chum = Chum Salmon
Chin= chinook salmon, SK= sockeye salmon
a = Incomplete surveys
b = Arctic grayling and slimy sculpin survey data not available
c = Species present but spawning activity not confirmed

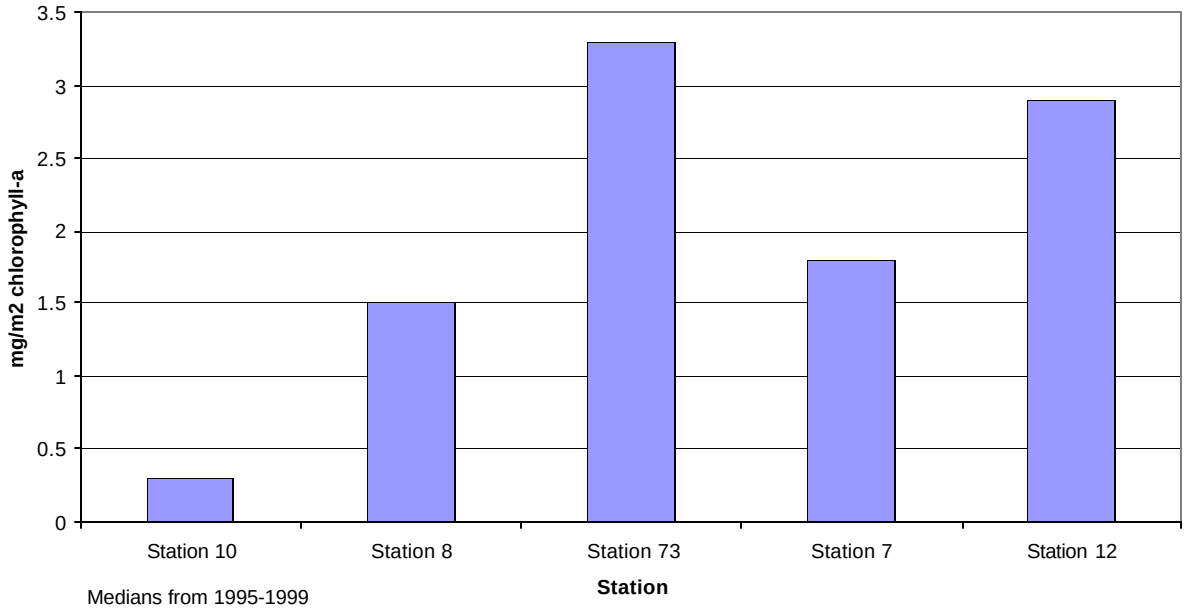
3.2.2 Aquatic Invertebrate Communities

Few aquatic invertebrate studies have been conducted in the affected area. The benthic community found in Mainstem Red Dog Creek by ADF&G (1998) has low species abundance and richness. The dominant taxon in most years is Diptera. The benthic community in North Fork Red Dog Creek includes ten different taxonomic groups including pollution-sensitive taxa such as Ephemeroptera, Plecoptera, and Trichoptera, typical of high-latitude streams. ADF&G (1998) reported a low number of taxa (less than 2) at Stations 8 (located in Ikalukrok Creek just below the confluence of Mainstem Red Dog Creek) and 10 (located in Mainstem Red Dog Creek) collected with kick nets but a greater average number of taxa collected with drift nets in the summer of 1996 (4 to 9 taxa). Seasonal differences, different sampling methods, and timing of emergence account for differences in the number of taxa collected. The dominant taxa at all stations (10, 8, 7, and upstream in Dudd Creek) were similar. The insect order Diptera was the most abundant with Chironomids and Simuliidae. Plecoptera was the second abundant order represented mainly by Capniidae, and Ephemeroptera (mostly Heptageniidae) was the third most prevalent insect order at all stations.

3.2.3 Periphyton

ADF&G has been monitoring the presence of periphyton by measuring concentrations of chlorophyll-a on the surface of rocks collected from streams in the vicinity of Red Dog Mine. Low biomass (as reflected

Figure 4. Median Values of Periphyton in Red Dog and Ikalukrok Creeks, 1995 - 1999



by chlorophyll-a concentrations) has been documented in Ikalukrok Creek at Station 8 just below the confluence of Mainstem Red Dog Creek; values are even lower in Mainstem Red Dog Creek. Figure 4 compares the median chlorophyll-a concentrations between several stations over a several-year period.

4.0 Environmental Consequences

4.1 Water Resources

4.1.1 Hydrology and Stream Flow

The original NPDES permit contained discharge limits of 7.1 million gallons per day (mgd) (daily maximum) and 5.4 mgd (monthly average). The 1998 permit contains an annual discharge limit of 2.418 bgy (billion gallons per year). This limit would be the same under either the proposed action or the alternative. This permit modification will not specify how much flow volume should be discharged at a particular time.

However, the permit modification will affect the timing of when various flow volumes are released. Generally, flow discharges from the mine will be high when natural in-stream flow volumes are high and low when natural in-stream flow volumes are low.

4.1.2 Water Quality

Operation of the Red Dog Mine, including the mine water treatment system, has caused increased levels of TDS in Mainstem Red Dog Creek and at points downsteam. These changes are produced by the mine water treatment system, which uses lime and sodium sulfide precipitation to remove metals from the effluent prior to discharge. Metal sulfates dissolved in mine water are removed by the lime treatment process and precipitated as metal hydroxides. Calcium and magnesium sulfate remain in solution and are the primary source of TDS in the effluent. As stated previously, effluent TDS concentration in 2002 ranged from 1,710 mg/L to 3,640 mg/L with a median concentration of 3,430 mg/L. Teck Cominco's treatment system is designed so that they can regulate effluent flow volume to adjust for in-stream changes in TDS based on a correlation algorithm from measured conductivity readings at the downstream monitoring stations.

Proposed Action: Modify TDS Limits in NPDES Permit

The proposed action would result in modification to the present NPDES permit for the Red Dog Mine. The modification would include the following:

1. No discharge is allowed until after Arctic grayling have finished spawning.

2. In Mainstem Red Dog Creek after Arctic grayling have finished spawning, the effluent discharge is limited so as to maintain TDS concentrations at or below 1,500 mg/L outside of the proposed mixing zone (see section 2.1.1 for location of proposed mixing zone). Field observations will be used each year to determine when spawning is complete.

3. In Ikalukrok Creek after Arctic grayling have finished spawning, the effluent discharge is limited so as to maintain TDS concentrations at or below 1,000 mg/L outside of the proposed mixing zone (see section 2.1.1 for location of proposed mixing zone).

4. During the salmon and Dolly Varden spawning seasons in Ikalukrok Creek, the effluent discharge is limited so as to maintain TDS concentration at or below 500 mg/L in fish spawning habitat (spawning occurs from July 25th through the end of the discharge season).

As explained in Section 2.1.1, monitoring data gathered from Station 10 (Mainstem Red Dog Creek below the proposed mixing zone) will be used to ensure that the proposed site-specific criterion is being met outside of the proposed mixing zone in Mainstem Red Dog Creek. Table 3 in Section 3.1.2 shows that

the median concentration of TDS in Mainstem Red Dog Creek at Station 10 (1,090 mg/L) measured from 1999 through 2002 is less than the State's site-specific criterion of 1,500 mg/L (which would apply at the outside of the proposed mixing zone in Mainstem Red Dog Creek). However, 16 of 115 measurements (14% of the measurements) at this station during this time period exceeded the proposed site-specific criterion value of 1,500 mg/L. As noted in Section 3.1.2., the compliance order which the facility was operating under allowed the facility to discharge up to 1,600 mg/L for up to 48 hours in any 10-day period. Only three of the 115 measurements (~3 percent) exceeded 1,600 mg/L.

As explained in Section 2.1.1., monitoring data gathered from Station 150 (Ikalukrok Creek approximately 150 feet below the proposed mixing zone) will be used to ensure that the TDS criterion is being met at the outside of the proposed mixing zone in Ikalukrok Creek. Table 3 shows the concentrations of TDS measured from 2001 through 2002 at Station 150. At Station 150 the applicable criterion, based on Alaska's revised water quality standards for TDS, is 1,000 mg/L. None of the 73 measurements taken at station 150 during this time period exceeded the 1,000 mg/L criterion.

Monitoring data gathered at Station 160 (Ikalukrok Creek approximately 3 miles below Dudd Creek and above the known spawning areas of salmon and Dolly Varden) will be used to ensure that Alaska's revised water quality standard for TDS of 500 mg/L is being met in spawning areas in the Ikalukrok Creek when spawning is occurring. Table 3 shows the concentrations of TDS at Station 160 (measured from 1999 through 2002). Only one of the measurements at station 160 exceeded the 500 mg/L criterion during the spawning period (as stated in the EPA compliance order).

Within the mixing zones proposed for the permit modification, TDS values would exceed the proposed criteria values at certain locations, due to incomplete mixing of the effluent and the receiving water. The maximum value that could occur inside the Mainstem Red Dog Creek mixing zone is equivalent to the TDS concentration at the mine outfall discharge point, and the maximum value that could occur in the Ikalukrok Creek mixing zone is equivalent to the TDS concentration at Station 10 (located in Mainstem Red Dog Creek). TDS values in Mainstem Red Dog Creek would meet the criteria outside of the mixing zone, where the effluent is fully mixed with North Fork Red Dog Creek water. Similarly, TDS values in Ikalukrok Creek would meet the criteria outside the mixing zone, where the water from Mainstem Red Dog Creek is fully mixed with the water from the upper Ikalukrok Creek.

While TDS values at specific locations within the mixing zone in Red Dog Creek exceed values that would be protective of aquatic life (1,500 mg/L), there is a zone within the length of the mixing zone which would allow aquatic life to avoid the higher TDS water if necessary. Likewise, while TDS values within the mixing zone in Ikalukrok Creek would exceed the State's criterion of 1,000 mg/L, there is a zone within the length of the mixing zone that would allow aquatic life to avoid the higher TDS water. Additionally, the highest

TDS value expected in the Ikalukrok Creek mixing zone would be 1,500 mg/L, and available data suggest that this value is protective of aquatic life with the exception of spawning activities, which do not occur in this reach of the Ikalukrok Creek.

The proposed action would keep the elevated concentrations of TDS the same as they have been over the past several years, during which the mine has been operating under a compliance order from EPA that allows these higher TDS levels. Thus, the permit modification would essentially maintain the same TDS levels that have been discharged over the past several years. The potential effects to aquatic life from the proposed increase in the TDS limit are discussed in Section 4.2.

Alternative: Maintain TDS Limits in Current NPDES Permit

Under the alternative, there would be a substantial reduction in TDS in both Mainstem Red Dog Creek and in Ikalukrok Creek. Maximum concentrations would be at the point of discharge; the monthly average TDS concentrations could not exceed 170 mg/L and the daily average could not exceed 196 mg/L. Treatment and removal of about 95 percent of TDS in the mine effluent would be necessary to meet this limit.

4.2 Aquatic Resources

4.2.1 Fish

Proposed Action: Modify TDS Limits in NPDES Permit

Toxicity tests and field studies have been conducted to determine the effect that TDS concentrations are expected to have on salmonids and other fish. These studies are summarized below.

Toxicity Tests ADEC, the Alaska Department of Fish and Game(ADF&G), and EPA developed toxicity test to determine the potential impacts on fish from TDS concentrations similar to Red Dog effluent. These laboratory toxicity procedures included tests for determining the effects of simulated Red Dog Mine TDS (see page 11 for the chemical composition of Red Dog Mine TDS) on various life stages of fish and invertebrates. In 1996, EVS Environment Consultants conducted TDS toxicity tests for Red Dog Mine effluent using the testing protocols developed by EPA, ADEC, and ADF&G. Fertilized eggs and swim-up fry of rainbow trout (*Onchoryncus mykiss*) were exposed to a range of TDS concentrations. The highest TDS concentrations tested (in the range of 1,993 to 2,757 mg/L) did not affect rainbow trout embryo viability, rainbow trout fry survival, or growth. The results from of these laboratory tests are presented in Table 5.

Literature Survey ADF&G Technical Report 01-06 - *Effects of Total Dissolved Solids on Aquatic Organisms* June 2001- presents a thorough literature review of TDS toxicity (ADF&G 2001b). It summarizes and evaluates the results from 28 studies dealing with the effects of TDS on aquatic life. The overall conclusions from the ADF&G report are:

1. Toxicity is due primarily to ionic properties rather than osmotic effects.

2. For chum, coho, and Atlantic salmon; rainbow and brook trout; striped bass; and fathead minnow, the life stage most sensitive to TDS exposure is from fertilization through egg hardening.

3. Concentrations of TDS in the range of 750 mg/L significantly reduce fertilization and hatching rates in coho and chum salmon, and extends the development time to epiboly and the eyed-egg stage.

4. After egg hardening, fish do not appear to be affected by elevated concentrations of TDS up to 2,000 mg/L.

5. No detrimental effects of calcium sulfate were reported on fish sperm motility for concentrations of TDS below 3,000 mg/L.

This literature survey includes three studies that document adverse affects to fish fertilization prior to the egg hardening stage. A study by EVS *et al.* (1998) and an interim report from a two-year study by Stekoll *et al.* (2001) indicate that there may be adverse affects to development of salmon eggs and the long-term survival of salmon eggs when they are exposed to calcium-dominated TDS during the fertilization stage at TDS concentrations at or below 500 mg/L. An earlier study, Ketola *et al.* (1988), provides additional reason to examine the effects of 500 mg/L TDS concentration on fish fertilization. However, because of intra-test, inter-test, and inter-species variability, it is hard to precisely quantify the effect. Additional, laboratory tests are continuing, and ADEC had committed to revisit its criterion as new information becomes available.

Field Data Fisheries resources in Red Dog and Ikalukrok Creeks have been monitored since 1994, when ADF&G began a five-year study to document changes in fish species composition, distribution, relative abundance, and metal concentrations in adult Dolly Varden tissue. Surveys of chum salmon in Ikalukrok Creek started in 1996 to document their presence in the creek. From 1997 through 2002, ADF&G documented fish occurrence and sampled periphyton and aquatic invertebrate communities in receiving waters downstream of discharged treated mine effluent.

Table 5. Toxicity Tests on Rainbow Trout Conducted with Reconstituted Laboratory Water to Approximate Red Dog TDS Chemistry

Test Species	*Measurement Endpoint*	*Duration*	*Effect Concentration mg/L TDS*	*Reference*	*Comments*
Rainbow Trout	Embryo Viability	7 days	NOEC =1,993	EVS 1996	Eggs dry-fertilized and exposed for 4 days then 3 days of dilution water.
Rainbow Trout	Swim-up Fry - Mortality	7 days	NOEC = 2,099	EVS 1996	Eggs dry-fertilized and exposed for 4 days then 3 days of dilution water.
Rainbow Trout	Swim-up Fry - Growth	7 days	NOEC = 2,099	EVS 1996	Eggs dry-fertilized and exposed for 4 days then 3 days of dilution water.

NOEC means the no observed effect concentration.

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The following is a summary of relevant conclusions regarding salmonids and other fish cited by ADF&G (1998, 2000, and 2002). Details of ADF&G methods and findings may be obtained from their technical reports.

- *Chum Salmon Spawning* - Chum salmon spawning surveys were conducted in 1984, 1986, 1990, 1991, and 1995-2001 as well as during pre-mining in the early 1980s. In the early 1990s Chum salmon were adversely affected by mine drainage from the Red Dog Mine. In the mid-1990s, Teck Cominco remedied the problem by collecting its mine drainage and upgrading the treatment system to adequately treat its wastewater. Field surveys show an apparent trend of increasing numbers of chum salmon since the mid-1990s; however, the number of returning adult chum salmon spawners remain lower than pre-mining counts.

- *Overwintering Dolly Varden* - Populations of these fish fluctuate yearly; however, no changes have occurred in the numbers of overwintering Dolly Varden that are attributable to operations at the Red Dog Mine.

- *Fish Distribution* - Pre-mining fisheries studies suggest that Mainstem Red Dog Creek did not provide rearing habitat for juvenile Dolly Varden. Since 1995, these fish have been rearing in Mainstem Red Dog Creek, and the relative abundance of juvenile Dolly Varden appears to have increased since 1997.

- *Arctic grayling* - Recruitment of Arctic grayling and spawning success in North Fork Red Dog Creek have been near their highest levels since pre-mining time. Rearing of Arctic grayling have also been documented in Mainstem Red Dog Creek. It is believed that Arctic grayling spawn in Mainstem Red Dog Creek, but it has not been confirmed.

ADF&G (2000) stated:

> "We conclude that during 1998 and 1999, Teck Cominco Alaska Inc. operated the Red Dog Mine with no apparent adverse effect on fish migration to and use of North Fork Red Dog Creek. We did not observe fish kills in Mainstem Red Dog or Ikalukrok Creeks. Catches of juvenile Dolly Varden were high in all sample areas and recruitment of small Arctic grayling was the highest seen since sampling began in the early 1990s. Metals concentrations in 1996 through 1999 in Mainstem Red Dog Creek were lower than any concentrations reported during

baseline studies."

Fish (slimy sculpin, Dolly Varden, and Arctic grayling) are found in Mainstem Red Dog Creek. However, Arctic grayling are the only fish species that might spawn in Mainstem Red Dog Creek (lower portions of the creek); spawning occurs in the spring at breakup before the Red Dog Mine's TDS discharge begins.

Based on field studies that document the fish life stages present in Mainstem Red Dog Creek, the specific laboratory TDS toxicity studies completed for simulated Red Dog Mine TDS, and the literature review of other studies that characterize the effects of TDS on aquatic life, EPA believes that 1,500 mg/l TDS is protective for all fish life-stages found in Mainstem Red Dog Creek with the exception of the fertilization-to-egg-hardening phase. Arctic grayling spawning activities in Mainstem Red Dog Creek will be protected by limiting the timing of discharge to the period after Arctic grayling spawning is complete. To ensure adequate protection of Dolly Varden and salmon spawning in Ikalukrok Creek below Dudd Creek, a reduced discharge rate during low flow periods can control the downstream TDS concentrations to protective levels specified by the state-wide criterion (500 mg/L).

As for Alaska's state-wide criterion for TDS, EPA has asked Alaska to consider new research on the effects of TDS, particularly data related to the fertilization life-history stage (Stekoll *et al.* 2001) as it becomes available. Currently, there is one study suggesting spawning may be adversely affected by TDS levels less than the current state-wide criterion of 500 mg/l and two studies showing that 500 mg/L TDS is adequately protective of spawning. Further study is needed to ensure that this state-wide TDS criterion is adequate to protect this sensitive life-history phase from the effects of TDS exposure in Alaskan waters.

Alternative: Maintain TDS Limits in Current Permit

The alternative would require additional technology controls or water management controls to lower TDS in the effluent discharge so that TDS levels in Mainstem Red Dog Creek remain no greater than one-third above background TDS. This limit is based on a water quality standard for TDS which is no longer contained in Alaska's water quality standards.

As stated in Section 4.1.2, the proposed site-specific criterion of 1,500 mg/L TDS was exceeded approximately 14 percent of the time in Mainstem Red Dog Creek after Arctic grayling finished spawning. However, TDS levels in spawning areas in Ikalukrok Creek are consistently below the 500 mg/L TDS limit during the spawning period.

A substantial investment would be needed to reduce TDS to the permit limits in the current permit (see

Table 6). Andrews (1999) estimated that capital costs for various TDS management alternatives would range from $13 million to $60 million, and additional operating costs could range upwards of $750,000 per year. Alternatives evaluated included four treatment options and a pipeline to Ikalukrok.

Table 6. Estimated Construction and Operating Costs for TDS Management

Alternative management	*Construction costs*	*Operating costs ($/year)*	*Annual amortized capital cost*
Chemical treatment (sodium aluminate)	$13,780,000	$2,500,000	$1,850,000
Ion Exchange	$60,000,000	$3,500,000	$8,100,000
Reverse osmosis	$55,000,000	$3,000,000	$7,400,000
Biotreatment	$21,850,000	$2,500,000	$2,950,000
Pipeline to Ikalukrok	$15,265,000	$750,000	$2,100,000

Costs are as presented in Table 6 of Andrews 1999 and are reported to be accurate to within ±40 percent to ±50 percent.

As noted above, current conditions in the creek are supporting fish. Given the apparent absence of adverse effects on fish by the mine effluent, the substantial expenditures that would be required to reduce TDS levels by an estimated 90 to 95 percent would not be expected to provide commensurate environmental benefits.

4.2.2 Aquatic Invertebrate Communities

Proposed Action: Modify TDS Limits in NPDES Permit

The Proposed Action would increase TDS concentrations in Mainstem Red Dog Creek and Ikalukrok Creek to levels that exceed pre-mining background values but that remain within the range of current levels. Toxicity tests and field studies have been conducted to determine the effect that TDS concentrations are expected to have on aquatic invertebrate communities. These studies are summarized below (See Table 7). In general, the available data indicate that the proposed levels of TDS would not have an adverse impact on aquatic invertebrate communities.

Table 7. Toxicity Tests on Chironomid Larvae Conducted with Reconstituted Laboratory Water to Approximate Red Dog TDS Chemistry

Test Species	*Measurement Endpoint*	*Duration*	*Effect Concentration mg/L TDS*	*Reference*	*Comments*
Chironomid larvae	Survival	10 days	NOEC = 2,089	EVS 1996	Second-stage larvae at 23°C water temp. Exposure to synthetic effluent for 5 days then 5 days exposure to dilution water.
Chironomid larvae	Growth	10 days	NOEC = 1,584 LOEC = 2,089	EVS 1996	Second-stage larvae at 23°C water temp. Exposure to synthetic effluent for 5 days then 5 days exposure to dilution water.
Chironomid larvae	Survival	10 days	NOEC = 1,295 LOEC = 1,835 LC50 = 2,035	EPA 1999	< 24-hr old larvae at 23°C water temp.
Chironomid larvae	Length	10 days	NOEC = 2,400	EPA 1999	< 24-hr old larvae at 23°C water temp.
Chironomid larvae	Survival	10 days	NOEC = 2,540	EPA 1999	10-day old larvae at 23°C water temp.
Chironomid larvae	Weight	10 days	NOEC = 2,005 LOEC = 2,540 IC0 = 1,598	EPA 1999	10-day old larvae at 23°C water temp. Integrated survival and weight as Biomass, resulting in an estimated inhibition concentration.

NOEC means the no observed effect concentration
LOEC means the lowest observed effect concentration
IC0 means the inhibition concentration 0 or the concentration causing inhibition to 0% of the population
LC50 means the lethal concentration 50 or the concentration causing 50% mortality

Toxicity Tests ADEC, ADF&G, and EPA developed toxicity tests to determine the potential impact on aquatic invertebrates from TDS concentrations similar to Red Dog effluent. Both EVS (EVS 1996) and EPA (USEPA 1999) conducted toxicity tests on Chironomid larvae using simulated Red Dog effluent and the toxicity test methodology developed by ADEC, ADF&G, and EPA. Table 7 provides a summary of the results of the toxicity tests performed by EVS and EPA. The results of the toxicity tests are recorded in terms of one or more of the following parameters:

- NOEC, which is the "no observed effect concentration." It is the highest tested concentration at which no adverse effect was observed on the Chironomid.
- LOEC, which is the "lowest observed effect concentration." It is the lowest concentration that results in statistically significant adverse effects on the Chironomid.
- IC0, is the, inhibition concentration zero, or the concentration causing inhibition to 0% of the population.
- LC50, is the lethal concentration 50, or the concentration of TDS causing 50% mortality.

The lowest NOEC and LOEC of TDS, observed in various studies, for Chironomid survival was 1,295 mg/L and 1,835 mg/L, respectively. A regression analysis was used to calculate an IC0 of 1,598 mg/L TDS. These data indicate that adverse impacts to sensitive life stages of aquatic insect larvae could be expected at TDS concentrations greater than 1,500 mg/L TDS.

At Station 150 in Ikalukrok Creek the maximum recorded TDS concentration, based on data collected from 2001 through 2002 (when discharge limits under the compliance order were comparable to those under the proposed permit modification), was 876 mg/L (see Table 3), which is well below the NOEC; thus adverse impacts to aquatic invertebrates are not expected in Ikalukrok Creek. At Station 10 in Mainstem Red Dog Creek, the median TDS concentration of the data collected from 1999 through 2002 (again, under discharge conditions similar to those proposed in the permit modification) was 1,090 mg/L, which was below the NOEC value, and the maximum concentration was 1,820 mg/L (see Table 3), which was below the LOEC value. The permit will require the mine to limit its effluent discharge so that the in-stream concentration of TDS does not exceed 1,500 mg/L at any time in Mainstem Red Dog Creek. The toxicity tests indicate that adverse impacts to sensitive life stages of aquatic invertebrates are not expected.

Literature Survey The ADF&G literature survey reviews a number of studies that examined the effects of TDS on invertebrates. This literature survey concludes that aquatic invertebrate growth and survival is affected by concentrations of TDS greater than 1,500 mg/L (concentrations of TDS showing adverse effects ranged from 1,692 mg/l to greater than 2,430 mg/l). There were no reported adverse effects at concentrations below 1,692 mg/L.

Field Data ADF&G has monitored aquatic invertebrate communities in Mainstem Red Dog Creek, North Fork Red Dog Creek, and Ikalukrok Creek since 1996. Fish use of these creeks also has been monitored beginning in 1992. Taxonomic richness and density of periphyton and fish presence provide an overall measure of aquatic community diversity and complexity and use.

Both aquatic invertebrate density and abundance at Station 10 were among the lowest found. However, these populations respond to many environmental factors, including stream velocity, substrate, and water quality (especially metals content). Station 10 contained similar numbers of aquatic taxa as the other sites, an indication that community diversity and complexity were similar to the other sites. In 2002, concentrations of chlorophyll-a at Station 10 were among the highest measured.

Differences in fish use are often seen among years, but relative use by sites remains the same (i.e., high fish use in reference streams in a specific year corresponds with high use in Mainstem Red Dog Creek). Based on the current use of Mainstem Red Dog Creek as a rearing area by adult and age-0 Arctic grayling, juvenile Dolly Varden, and slimy sculpin, it is inferred that the food base is not being significantly impacted by existing TDS levels.

Alternative: Maintain TDS Limits in Current NPDES Permit

Under the alternative, TDS loadings (and resultant concentrations) in Mainstem Red Dog Creek and Ikalukrok Creek would be reduced by over 90 percent. Because existing discharges have apparently not had a significant impact on aquatic invertebrates, there are no data suggesting that such a TDS reduction would have a significant impact.

4.2.3 Periphyton

Proposed Action: Modify TDS Limits in NPDES Permit

Periphyton are generally sensitive to heavy metal contamination, particularly zinc. Algal biomass (chlorophyll-a) measurements were made on samples collected from the monitoring stations (large attached filamentous algae were not included in the study). In general, average concentrations of chlorophyll-a collected from Station 10 in Mainstem Red Dog Creek, are lower than those found in Ikalukrok or North Fork Red Dog Creeks, but substantially higher than in Middle Fork Red Dog Creek where the metals concentrations and TDS are highest. In 2002, concentrations of chlorophyll-a at Station 10 were among the highest measured. Toxicity tests with periphyton and treated Red Dog effluent have not been conducted. Correlations of algal biomass with metals concentrations were attempted by ADF&G (2000) but the relationships were weak and limited by small sample sizes. The ADF&G literature survey found few studies that dealt with the effects of elevated TDS concentrations on fresh water algae. The ADF&G

survey concludes that no range of concentrations causing toxic responses could be determined from published reports.

Overall, it has not been possible to determine the influence of water quality, particularly TDS, on periphyton communities. Since periphyton are generally sensitive to changes in water quality and are measures of stream productivity, the lack of a measurable negative effect suggests that existing TDS levels are not causing an adverse effect to periphyton.

Alternative: Maintain TDS Limits in Current NPDES Permit

Based on the past monitoring data conducted by ADF&G, the attached periphyton community has not been significantly altered by the levels of TDS in Mainstem Red Dog Creek.

4.2.4 Other Potential Impacts

Red Dog Creek and Ikalukrok Creeks are not used for drinking water purposes, although a transient visitor may occasionally drink the water. Ikalukrok Creek does flow into the Wulik River which is used as drinking water by the village of Kivalina. Residents of Kivalina have reported that the taste of their drinking water has changed since the Red Dog Mine started operations. EPA has reviewed water quality data from Station 1 (located in the Wulik River approximately 2.5 miles upstream of Kivalina). While the data show there are metals in the water at concentrations that could affect the taste of drinking water, such as iron and manganese, there are no data suggesting that these metals are coming from the Red Dog mine site. Rather, based on data collected from Station 9 (Ikalukrok Creek above the confluence of Mainstem Red Dog Creek) they appear to be coming from Ikalukrok Creek above Mainstem Red Dog Creek, out of the influence of the mine's wastewater discharge. Another possible source contributing to the change in taste of the drinking water is the sulfate, or possibly calcium, from the Red Dog mine TDS. However, to date, it has not been possible to isolate the source of the taste change.

The National Primary Drinking Water Standards protect public health by limiting the level of contaminants in drinking water. EPA has not developed primary drinking water standards for TDS because TDS in drinking water is not a hazard to human health. EPA does recommend acceptable levels of TDS in drinking water in its National Secondary Drinking Water Regulations. These regulations provide non-mandatory recommendations for contaminants that can cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as changes in taste, odor, or color). EPA recommends TDS not exceed 500 mg/L in water used for drinking.

TDS sampling has been conducted in Mainstem Red Dog Creek, Ikalukrok Creek and the Wulik River (about 2.5 miles upstream of Kivalina). The data from 1999 through 2002 best reflects the conditions expected to be found in the creeks after the proposed modification because during this time period the facility was discharging under a compliance order that required the facility to meet conditions similar to the conditions in this proposed permit modification. The data show that the level of TDS exceeds the secondary drinking water standard (500 mg/L) 80% of the time in Mainstem Red Dog Creek, and 10% of the time in the Ikalukrok Creek. However, the TDS concentration in the Wulik River is always well below the recommended standard.

The National Secondary Drinking Water Standards also provide non-mandatory recommended concentrations for three of the constituents found in TDS: sodium, sulfate, and chloride. The secondary drinking water standard for sodium is 200 mg/L. Sodium can affect the taste of drinking water. Both sulfates and chlorides have a secondary drinking water standard of 250 mg/L. Both of these constituents can affect taste and cause corrosion, and sulfates at high levels can cause laxative effects. These constituents of TDS were analyzed at Station 160 in the Ikalukrok Creek below Dudd Creek, and at Station 1 in the Wulik River about 2.5 miles upstream of Kivalina. In Ikalukrok Creek the data show that sodium and chloride are always well below the secondary drinking water standards, and sulfate is higher then the standard about 13% of the time. In the Wulik River, the data show that the constituents are always well below the secondary drinking water standards. Therefore, it is not expected that TDS will cause any adverse cosmetic effects or aesthetic effects. There are no data, reports, or other sources of information suggesting the possibility of any adverse human health effects at the levels observed in the Wulik River.

Occasionally wildlife will also drink water from the affected creeks. However, health effects to individual animals would depend on the quantity, frequency, and duration of exposure, along with potential avoidance behavior. It is not expected that wildlife populations would be adversely impacted by TDS levels in the affected stream reaches, although some short-term health effects to individuals may be possible.

4.3 Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Environmental impacts from the proposed action and the alternative related to TDS levels in Mainstem Red Dog Creek and Ikalukrok Creek would apply for the duration of activities associated with the operating life of the mine (approximately 20 years depending on economic conditions). Once the mine ceases production and depending on the mine closure plan, it is likely that pre-mining conditions will return, resulting in increased metal levels and decreased TDS. Likewise, metals available for uptake by the biota and the distribution of fishes may return to the pre-mining situation. For example, the use of Mainstem Red Dog Creek by Arctic grayling and slimy sculpin may be reduced.

Based on nearly a decade of environmental monitoring in the two creeks, the short-term increase in TDS as a result of the mine's discharge does not appear to have adversely impacted the aquatic system. Furthermore, the mine has provided a source of jobs to the area which is an economic benefit.

4.4 Irreversible and Irretrievable Commitments of Resources which would be Involved with the Proposed Action

The Council on Environmental Quality regulations for implementing the National Environmental Policy Act specify that the environmental analysis must address "any irreversible and irretrievable commitment of resources which would be involved in the proposed action should it be implemented." Irreversible effects primarily result from permanent use of a non-renewable resource (e.g., minerals, energy). Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (e.g., disturbance of a cultural site) or consumption of renewable resources that are not permanently lost (e.g., old growth forests).

The mining of the ore at Red Dog Mine represents an irreversible commitment of resources. The proposed action which involves the change of a water quality parameter (TDS) and the inclusion of two mixing zones in the existing NPDES permit is more narrow in scope. The proposed action does not result in the use of any non-renewable resources, and therefore does have irreversible effects.

The water quality has changed since the mine went into operation. Primarily, TDS concentrations have increased and metals concentrations have decreased since the mid-1990s. Fish surveys indicate that the present level of TDS is not having a negative impact on fish populations. The analysis in section 4.2.2 indicates that aquatic invertebrates are not adversely affected by TDS concentrations of 1,500 mg/l. Based on the definition above, there is no loss in value of the aquatic life and the water quality to support the aquatic community. Therefore, the action does not have irreversible effects on the aquatic community.

There may be an irretrievable effect on drinking water in the Wulik River because the villagers in Kivalina report that the water from the Wulik River tastes different when compared to pre-mining conditions. This represents a loss in value of a renewable resource which may possibly be due to the increased TDS concentrations. Although the water tastes different, based on the analysis in section 4.2.4, the proposed allowable increase in TDS concentrations in the Wulik River will not cause adverse effects to human health.

4.5 Secondary and Cumulative Impacts

Secondary impacts are those that are caused by an action and are later in time or farther removed in distance, but are still reasonably foreseeable. Cumulative impacts are effects that may be incrementally minor, but when considered in combination with other similar impacts may accumulate to more substantial proportions. No secondary impacts to the environment are expected as a result of the administrative change in permissible TDS levels. There are no foreseeable future discharges of metals or TDS into the Red Dog Creek and/or Ikalukrok Creek watersheds that would cumulatively impact the streams.

5.0 Mitigation Measures

The proposed action includes two significant measures that mitigate for fish. The first measure is will prohibit discharges from the mine until after resident Arctic grayling have completed their spawning cycle, usually in late May or early June. The second measure will be a permit limit of 500 mg/L on TDS discharged to Ikalukrok Creek during the salmon/Dolly Varden spawning period. Because of annual differences in ice breakup conditions, water temperatures, and water flows that affect spawning timing, continued fish monitoring is necessary to confirm their time of use. For the salmon species and Dolly Varden, the limit of 500 mg/L TDS must be met during the spawning period of these species (July 25th through the end of the discharge period). For Arctic grayling, a fixed window of presumed or typical spawning periods is not recommended at this time due to the uncertainties associated with predicting timing of spawning; therefore, field observations will be used each year to determine when spawning has been completed.

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